Retrofit Streetlights with LEDs

Street lighting constitutes a significant portion of municipal energy consumption and expenditures. By buying back streetlights from their utility provider, converting to energy-efficient fixtures, and procuring products and services in bulk, municipalities can achieve energy and financial savings. For many municipalities considering upgrades to their street lighting system, LEDs have become a viable option. In addition to its environmental and economic benefits, undergoing a system-wide conversion can provide an opportunity for a municipality to standardize certain fixture types and styles, which can help create a unified aesthetic appearance or signature statement for a community. The benefits of LED lighting include:

- Decreased energy consumption and costs
- Reduced maintenance costs due to longer life
- Visible commitment to efficiency
- Improved safety through enhanced visibility
- Decreased light trespass and pollution
- Instant-on
- Opportunity for programmable controls
- No mercury, lead, or other known disposable hazards

This guide outlines the planning process for a conversion to exterior LED lighting systems, describes options for implementing projects, and summarizes available resources for cities and towns. It includes the following sections:

- Developing a Scope of Work
- Street Lighting Design and Fixture Selection
- Project Implementation, Procurement, and Financing
- Glossary of Lighting Terminology and Common Fixture Types
- Additional Resources

Developing a Scope of Work

There are a variety of ways in which a municipality can convert its street lighting system to LEDs, and the most appropriate will vary based on the municipality's individual scope of work. The following is a general guideline for approaching the process.

1. Conduct preliminary research and build the business case for retrofits.

In order to build the case for implementing an LED streetlight retrofit project to both residents and municipal officials, research into the following areas is helpful. The Massachusetts Department of Energy Resources, vendors on the state contract, and the Illuminating Engineering Society (IES) can aid such research.

- **Lighting terminology and technology –** Refer to the Glossary later in this guide for an overview of lighting terminology and technology.
- **Streetlight ownership status and inventory –** Figure out what streetlights the municipality owns and if there are plans to purchase streetlights from the utility. (See the Buy Back Streetlights from Utility strategy for more information on how to buy back lights.)
- **Metered, decorative, or outdoor area lights inventory –** Figure out if the municipality has any decorative/metered lights and whether it wants to replace them.
- **Case studies –** Interview other municipalities that have already completed LED streetlight retrofits to obtain anecdotal information on the potential for savings. Case studies and fact sheets are also available from the Municipal Solid-State Street Lighting Consortium.
- **Maintenance costs –** While there are up-front costs associated with fixture replacement and installation, keep in mind that maintenance costs are generally reduced due to LED bulbs' longer life span.
- **Procurement pathways –** Decide whether the municipality will purchase the fixtures or procure design, installation, and maintenance services. Identify in-house capacity for these various components and proceed accordingly with the required procurement processes.
- **Utility incentives –** NSTAR and National Grid are offer lighting retrofit incentives via the Mass Save program. Contact your utility lighting program coordinator to learn more.
- **Tariff changes –** Both NSTAR and National Grid have developed tariffs specifically for LED lights. Be mindful of what rate any new LED streetlights would be on to ensure that any potential cost savings are accurately depicted.
- **Calculating savings for different lights** – There are currently viable LED replacements for a wide variety of lights in addition to traditional cobrahead streetlights, including decorative pole lights, parking lot lights, flood lights, and wallpacks. The process for

receiving utility incentives and recouping energy cost savings is different for streetlights and these other lighting types due to the fact that streetlights are billed for electricity based on a tariff calculation and the other lighting types are billed based on actual metered consumption.

- **Streetlights** – Streetlights (e.g., cobraheads) are not individually metered for energy consumption. Instead, they are billed based on a predetermined formula for energy consumption called a *tariff*. Utility incentives for replacements of these types of fixtures are calculated based on estimated kWh savings and are currently determined on a case-by-case basis. Municipal utility tariffs and incentives will vary based on the utility. NSTAR is able to calculate a change in power consumption by comparing the existing fixture with the proposed replacement. National Grid has a tariff for LED technologies that approximates reductions in energy consumption using 50-watt brackets.

- **Metered lights** – Individually metered lights, such as decorative post-to fixtures, parking lot lights, flood lights, and wallighters are not subject to tariff issues. Municipalities can replace these immediately, and this may be the preferred course of action to become familiar with LED lights. The incentives for these fixtures are prescriptive (i.e., predetermined based on the fixture), but fixtures must have an Energy Star rating and/or be on the Design Lighting Consortium list of qualified products.

2. Hold kick-off meeting and form project team.

Completing an LED street lighting retrofit project will require support from multiple departments, and a well-balanced project team can be helpful to cultivate and maintain buy-in throughout the course of the project. Once a municipality has identified an interest in pursuing LED streetlight retrofits, it should hold a kick-off meeting to discuss the potential project scope with key stakeholders. These can include staff from the following departments, who should be invited to discuss their role in any potential project and to address any questions and concerns upfront:

- **Public Works** will need to be involved in providing information on existing street lighting infrastructure (condition/age, fixture type, maintenance requirements), as well as overseeing actual project construction.

- **Engineering** will need to be involved in assessing the feasibility of proposed retrofits.

- **Planning/Community Development** will need to be involved in classifying streets/neighborhoods, identifying desired/appropriate lighting levels, and collecting public input on pilot programs.

- **Administration/Finance** will need to be involved in securing funding/financing for projects and approving final budgets and contracts.

- **General Counsel** will also need to approve contracts and should be engaged early on, particularly if they are unfamiliar with the procurement and contracting methods chosen (e.g., contracting for energy management services pursuant to M.G.L. 25A requirements).

- **Procurement** will need to be involved in identifying the appropriate procurement pathway for materials and labor, and putting projects out to bid.

- **Energy Committee and/or Staff**, if applicable, can be tasked with coordinating project team, summarizing research, and filling in staffing gaps as needed.

- **Public Safety** representatives may want to be engaged in this, conversation as well.

Key decision points to be discussed with the project team and at the kick-off meeting include:

- Will there be a pilot program? At what stage in the project? How will the information be used?
- Will the energy committee interview vendors on the state contract and bring back a report to present to the city council/board of selectmen?
- Who will decide the best procurement pathway?
- Will a lighting consultant be hired?
- Is funding available or is there support for a financing option?
- Will fixtures and labor be procured separately? What about design work?
- Should decorative/metered lights be included?
- Is there an interest in having controls or renewable energy backups?

3. Prepare project scope and budget.

The specific parameters of the project will determine the funding needed.

- Establish whether the entire lighting system is being retrofitted or just a small section, based on availability of funds.
- Determine whether a streetlight inventory audit is required. The audit should use Geographic Information Systems (GIS) to record the location of each streetlight as well as attributes relative to retrofitting and maintaining the lights. Most of this information is not included in the utility's inventory and it can play an important role in billing and retrofit design, as discussed in the Considerations for Streetlight Audit section.
- Develop desired performance specifications for all of the streetlights that retrofits are planned for, based on the street lighting energy audit and/or improvement guidelines.
- Ensure that the LED lights being considered have an adequate warranty that covers the product for a sufficient period of time (e.g., 10 years). Good warranties span a significant portion of the lifetime of the lights and will cover not just the LED components but the driver and photocell, as well.

- Decide on the controls for the LED technologies. The types of controls (basic photocells, motion sensors, dimmers, advanced panels) depend on the amount of flexibility desired for the different types of LED light uses. For example, a combination of motion sensors and dimmers could be implemented in parking garages, while solar-powered cells could be useful in emergency situations and grid outages.
- With a complete specifications list in place, identify which procurement mechanism is most appropriate. Refer to the Project Implementation, Procurement, and Financing section of this document for more information.

Considerations for Streetlight Audit

Note: The following section discusses a **streetlight inventory audit**, which is different than an **Investment Grade Energy Audit (IGA).** A streetlight inventory audit creates an inventory of streetlights by using GIS to capture location data for each pole, along with attributes such as light wattage, light and pole type, pole and arm condition, pole height, arm length, potential issues such as damage or tree blockage, etc. An IGA identifies energy conservation measures and provides estimates of cost, savings, payback and a savings guarantee, used to determine whether to proceed with a project. The IGA is required for an Energy Management Services contract through M.G.L Chapter 25A Sections 11c or 11i. The IGA may involve a streetlight inventory audit, but not always (for example, the IGA may use the utility's existing inventory as the basis of its calculations). See Use a Performance Contract for Municipal Energy Efficiency Projects strategy for more on the IGA and streetlight specific considerations.

A streetlight inventory audit can be a useful tool to increase the accuracy of cost and savings estimates, improve design, accelerate installation, and manage long-term maintenance; however, it is not needed for every retrofit.

Due to the fact that most streetlights are unmetered and not associated with a specific address, tracking can be challenging. As a result, many utility inventories often list unmetered streetlights that no longer exist or may have inaccurate assumptions about wattage. A GIS inventory audit provides the location specific data to verify the utility inventory. If there are discrepancies that have resulted in over-billing the municipality, then they can be corrected, saving money in the future and potentially allowing for reimbursements of past over-billing.

The location-based data also enables location-based design. As described in Streetlight Design & Fixture Selection, a major aspect of streetlight design is selecting the appropriate amount of light. The selection is primarily based on the uses of the road and sidewalks below the light. However, other factors may impact the amount of light desired, such as presence of schools, playgrounds, parks, and prevalence of traffic accidents or crime. With a GIS layer of streetlights, a designer can map such data on top of the streetlights to allow for location-specific adjustments to standard replacement plans. LED streetlights now have warranties of 10 years and are expected to last over 20 years. As a result, the design benefits of a streetlight inventory audit will be visible for years to come.

The exact fixture counts and accurate wattages returned by the streetlight inventory audit have financial benefits for the project as well. It improves the accuracy of cost, saving, and payback estimates. Once the final design is approved, it minimizes potentially costly change orders. It also enables precise ordering which avoids over-purchasing and avoids delays if different quantities or wattages of lights are needed. Further, the audit will identify issues that must be addressed prior to installation, such as trees blocking access to the light. Discovering these issues ahead of time means they can be resolved and will not cause delays during installation. Any delay with streetlight retrofit delays the start of savings on utility bills and maintenance.

Once the retrofit is completed, the contractor will update the GIS streetlight inventory to match the new conditions. This inventory can be mapped in GIS software and viewed as a spreadsheet. The inventory is very useful for the long-term management and maintenance of the streetlights.

It is important to note that a GIS streetlight inventory can be collected during installation instead of before. Taking the GIS inventory during installation costs less than at an audit, because the crew does not need to make a separate trip. Additionally, it still provides the data for making billing adjustments with the utility and long-term management and maintenance. It does not, however, benefit design and installation as described above.

Streetlight inventory audits typically comprise only about 5% of the cost of the streetlight retrofit (design, product, and installation). Streetlight audits can make sense for communities of any size, but often they are most useful in larger municipalities that have more streetlights. The denser and more complex road systems make inaccurate tracking - and therefore billing inaccuracies - more likely. These also tend to have greater diversity of street lighting styles, pedestrian and motorist uses, and other factors such as accidents, crime or unique land uses that warrant location-specific design.

Streetlight Design and Fixture Selection

This section of the guide was developed thanks to Paul Lutkevich, Vice President, Technical Director, Parsons Brinckerhoff.

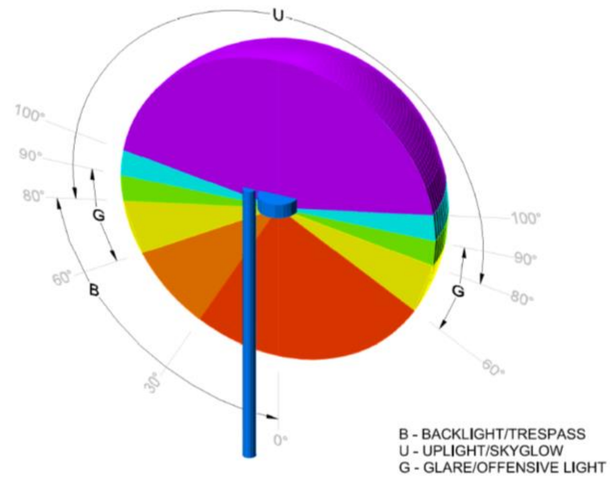
The following are important factors to consider in choosing fixtures for an LED street lighting conversion.

Fixture

- **Equivalency** – When considering replacement fixtures for a street lighting system the aim is often finding “equivalent” fixtures to the existing ones that consume less power. This approach is relatively simple but assumes that the existing fixtures provide appropriate light levels. It also relies on judgments of equivalencies made by simply using source wattages and not required photometric performance. When evaluating proper replacement fixtures, some typical streets should be evaluated by comparing the LED fixtures under consideration with current lighting recommendations. This comparison can simply be done by performing lighting calculations for these streets showing expected results. These calculations can be performed by a lighting engineer or often can be provided by the lighting fixture manufacturer of the chosen product.

- **Expected life and performance** – LED fixtures are very different from currently used lamp technologies. The key in achieving system performance and expected life from LED fixtures is heat management. Heat is managed by the fixture design as well as the rating of the LEDs used and the current at which they are operated. For example, an LED that is operated at a higher drive current and having a higher output will lead to a less-efficient and shorter-lived LED and driver. When evaluating LED fixtures, refer to the following test reports:
  - LM-79 Electrical and Photometric Measurements of Solid-State Lighting Products –This report gives the photometric performance of the fixture under consideration.
  - LM-80 Measuring Lumen Maintenance of LED Light Sources – This report gives the expected life of the LEDs based on the lumen depreciation of the source.
- **Color** – Various products use LEDs that produce various shades of "white" light. The color is a function of the phosphor coating used on the LEDs. The color is defined in terms of correlated color temperature (CCT). Street lighting fixtures are typically in the range of 4,000K and 5,700K. To an observer, the high CCT sources will appear "cooler" with more blue content to the source, while the lower CCT sources will have a "warmer" appearance with more "red" content. Color preference is subjective, and many users decide on sources with a CCT of between 4,000K and 5,000K.
- **Construction** – Material and construction is indicative of the expected life of the fixture. Reviewing available test reports for the fixture can offer an idea of the quality of construction. Tests which should be available for review include salt spray or salt fog testing, vibration testing, and the IP testing report, which rates the Ingress Protection of the fixture against solids and liquids. An IP designation typically uses two digits to identify the amount of protection a fixture has, with higher numbers noting greater protection. Roadway fixtures are typically rated an IP65 (with the 6 meaning totally protected against dust and the 5 meaning that it is protected against low pressure jets of water from all directions – limited ingress). Many fixture are also rated IP66, showing increased protection against liquid ingress and should be considered. Surge suppression is an important option for solid-state devices like LEDs, and many fixtures can provide surge suppression of up to 10 kV. The fixture warranty can also give some indication of the construction. Most LED streetlights are available with at least a five-year warranty, with some offering a ten-year warranty. The terms of the warranty are important to review, as some include labor, other just parts, as well as other coverage limitations.

- **Optical Control** – Optical control is an important factor to consider, particularly relating to lighting trespass, sky glow, and glare. Lighting calculations will quantify these impacts for the fixture under consideration. Another means is the BUG rating system developed by the IES. This system classifies the amount of Backlight, Uplight, and Glare they produce. The higher the BUG rating, the more of each of these items they produce. The correct BUG rating for an installation depends on many factors. Typically, ratings of B2-U1-G2 have been found to be acceptable.



- **Style and Finish** – LED fixtures come in various styles, ranging from contemporary to utilitarian to period reproduction styles. Before selecting a style, evaluate higher-volume streets like a downtown area and decide whether a unifying style or color may assist in creating an image or place within the community. The investment in a lighting retrofit can provide benefits beyond energy and maintenance savings and should be considered as part of the community planning and development process.

Area to be Illuminated

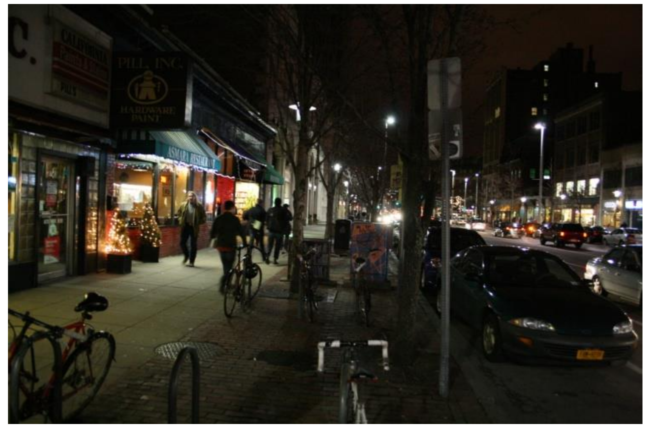
The lighting criteria used for street lighting is a compilation of standards and research from IES, the Federal Highway Administration (FHWA), the Transportation Association of Canada (TAC), the International Commission on Illumination (CIE), and the British Institute of Lighting Engineers (ILE). Specific documents include:

- IES TM-11 Light Trespass: Research, Results and Recommendations
- IES DG-5 Recommended Lighting for Walkways and Class 1 Bikeways
- IES DG-19 Design Guide for Roundabout Lighting
- IES RP-22 Standard Practice for Tunnel Lighting
- IES RP-20 Lighting for Parking Facilities
- IES TM-15 Luminaire Classification System for Outdoor Luminaires
- IES RP-33 Lighting for Exterior Environments
- IES RP-8 Standard Practice for Roadway Lighting
- TAC Guide for the Design of Roadway Lighting
- ILE Code of Practice for Variable Lighting Levels for Highways
- CIE 92.1 Guide to the Lighting of Urban Areas

Street lighting design is typically based on luminance-based design criteria for the roadway and horizontal and vertical illuminance criteria for the adjacent sidewalk area. Veiling luminance criteria are also included to limit the amount of disability glare generated by the lighting system.

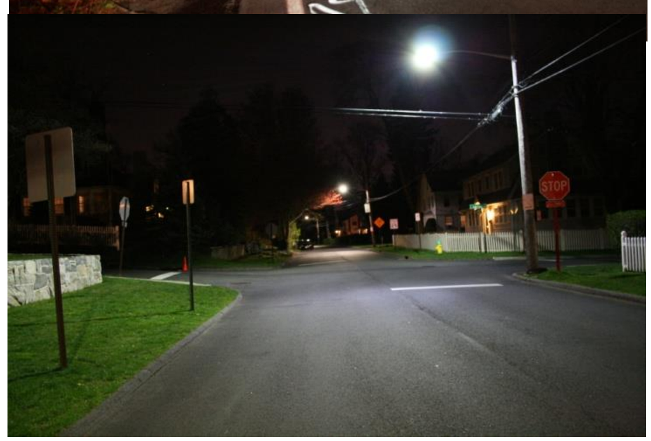
The following definitions are excerpted from IES RP-8 Standard Practice for Roadway Lighting.

- **Roadways**
  - **Major** – That part of the roadway system that serves as the principal network for through- traffic flow. The routes connect areas of principal traffic generation and important rural roadways leaving the city. These routes are often known as arterials," "thoroughfares," or "preferentials." They are sometimes subdivided into primary and secondary; however, such distinctions are not necessary in roadway lighting.



  - **Collector** – Roadways servicing traffic between major and local streets. These are streets used mainly for traffic movements within residential, commercial, and industrial areas. They do not handle long, through trips. Collector streets may be used for truck or bus movements and give direct service to abutting properties.

  - **Local** – Local streets are used primarily for direct access to residential, commercial, industrial, or other abutting property. They make up a large percentage of the total street system, but carry a small proportion of vehicular traffic.



- **Pedestrian areas**
  - **High** – Areas with significant numbers of pedestrians expected to be on the sidewalks or crossing the streets during darkness. Examples are downtown retail areas and near theaters, concert halls, stadiums, and transit terminals. (Over 100 pedestrians per hour in a typical block on both sides of the street)

- **Medium** – Areas where lesser numbers of pedestrians utilize the streets at night. Typical are downtown office areas, blocks with libraries, apartments, neighborhood shopping, industrial, older city areas, and streets with transit lines. (11 to 100 pedestrians per hour in a typical block on both sides of the street)

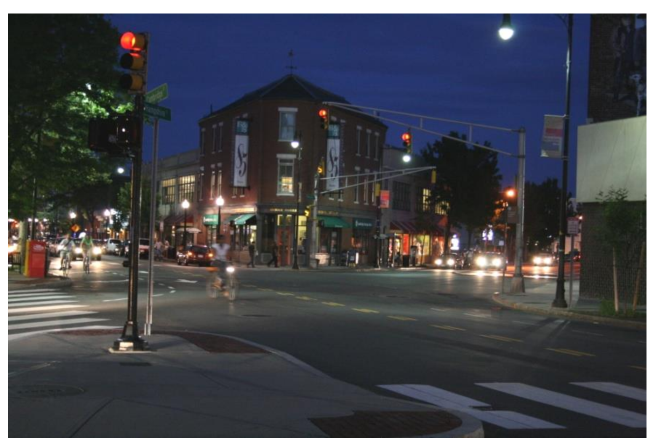
- **Low** – Areas with very low volumes of night pedestrian usage. These can occur in any of the cited roadway classifications but may be typified by suburban single family streets, very low density residential developments, and rural or semi-rural areas. (10 or fewer pedestrians per hour in a typical block on both sides of the street)

The recommended lighting levels for street lighting are:

Road and Area Classification		Avg. Lumin.	Max Uniform. Ratio	Max Uniform. Ratio	Max Veiling Lumin. Ratio
Road	Pedestrian	L_{avg} (cd/m²)	L_{avg}/L_{min}	L_{max}/L_{min}	L_{vmax}/L_{avg}
Major	High	1.2	3.0	5.0	0.3
	Medium	0.9	3.0	5.0	0.3
	Low	0.6	3.5	6.0	0.3
Collector	High	0.8	3.0	5.0	0.4
	Medium	0.6	3.5	6.0	0.4
	Low	0.4	4.0	8.0	0.4
Local	High	0.6	6.0	10.0	0.4
	Medium	0.5	6.0	10.0	0.4
	Low	0.3	6.0	10.0	0.4

- **Pedestrian areas and bikeways** – When the roadway includes a bikeway or a sidewalk, additional lighting recommendations are given by the IES to allow for reliable detection of pedestrians and cyclists by a motorist, as well as allowing facial recognition and a sense of security for the pedestrian. These areas are described by the total expected pedestrian volumes.

  - **High pedestrian conflict area** – High pedestrian conflict areas are going to be those with mixed commercial and residential use. Typical streets that would fall into this classification would be main streets through a city or town center where there is fairly dense development. A typical city or town would have very few areas of high pedestrian use.



The recommended values for high pedestrian conflict areas are:

Maintained Illuminance Values for Walkways			
	E_H (lux/fc)	E_{Vmin} (lux/fc)	E_{avg}/E_{min}*
Mixed Vehicle and Pedestrian	20.0/2.0	10.0/1.0	4.0
Pedestrian Only	10.0/1.0	5.0/0.5	4.0

* Horizontal only
E_H - average horizontal illuminance at pavement
E_{Vmin} - minimum vertical illuminance at 1.5m above pavement

- **Medium pedestrian conflict areas** – Intermediate areas have moderate night pedestrian activities. These areas may typically be those near community facilities such as libraries and recreation centers. Safety for the pedestrians and providing guidance to primary travel ways, are key elements in the design of a lighting system in these areas. These values do not consider areas with increased crime and vandalism.

The recommended values for medium pedestrian conflict areas are:

Maintained Illuminance Values for Walkways			
	E_H (lux/fc)	E_{Vmin} (lux/fc)	E_{avg}/E_{min}*
Pedestrian Areas	5.0/0.5	2.0/0.2	4.0

* Horizontal only

- **Low pedestrian conflict areas** – The lighting system in residential areas may allow both driver and pedestrian to visually orient in the environment, detect obstacles, identify other pedestrians, read street signs, and recognize landmarks. Table 7 includes recommended illuminance values. These values do not consider areas with increased crime and vandalism.

The recommended values for low pedestrian conflict areas are:

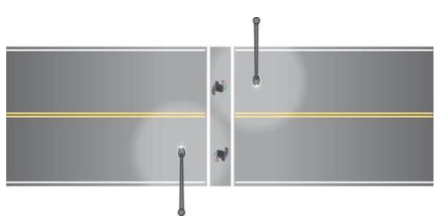
Maintained Illuminance Values for Walkways

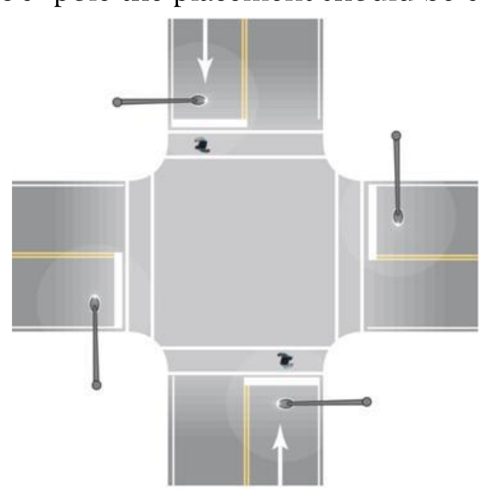
	E_H (lux/fc)	E_{Vmin} (lux/fc)	E_{avg}/E_{min}*
Low Density Residential	3.0/0.3	0.8/0.08	6.0
Medium Density Residential	4.0/0.4	1.0/0.1	4.0

* Horizontal only

- **Crosswalks** – An extensive study was conducted by the FHWA and VTTI concerning the lighting of crosswalks. The information is based on static and dynamic experiments performed at the Virginia Tech Transportation Institute and documented in FHWA-HRT-08-052, available at NTIS under publication number PB2008-106431. The finding and recommendations of the study are:
  - A vertical illuminance level of 20 lx measured at 1.5 m (5 ft) from the road surface allowed drivers to detect pedestrians in midblock crosswalks at adequate distances under rural conditions.
  - A higher level of vertical illuminance may be required for crosswalks when there is a possibility of continuous glare from opposing vehicles, the crosswalk is located in an area with high ambient light levels, or the crosswalk is located at a lighted intersection.
  - The fixture selected will influence the best mounting location and height with respect to the crosswalk.
  - The vertical illuminance level that allowed drivers to detect pedestrians at adequate distances was the same for HPS and MH sources; however, MH or other white light sources may provide better facial recognition and comfort for pedestrians.

  For lighting of crosswalks, poles should be placed on the approach side of mid-block crosswalks and crosswalks located at intersections. The lighting level in the crosswalk should be equivalent to 20 lux vertical. This can generally be accomplished by placing the pole 0.7 x mounting heights before the crosswalk (e.g., for a 30' pole the placement should be 0.7 x 30 = 21' before the center of the crosswalk).





- **Intersections** – Intersections should be illuminated to the sum of the intersecting streets. The area within the intersection that is required to meet these elevated levels is defined by the area in the center of the intersection to the location of the stop bars at each intersecting street.

The recommended values for intersections are:

Illumination for Intersections				
Functional Classification	Average Maintained Illumination at Pavement by Pedestrian Area Classification in Lux/fc			E_{avg}/E_{min}
	High	Medium	Low	
Major/Major	34.0/3.4	26.0/2.6	18.0/1.8	3.0
Major/Collector	29.0/2.9	22.0/2.2	15.0/1.5	3.0
Major/Local	26.0/2.6	20.0/2.0	13.0/1.3	3.0
Collector/Collector	24.0/2.4	18.0/1/8	12.0/1.2	4.0
Collector/Local	21.0/2.1	16.0/1.6	10.0/1.0	4.0
Local/Local	18.0/1.8	14.0/1.4	8.0/0.8	6.0

Project Implementation, Procurement, and Financing

After establishing a clear project scope, cost, and timeline, the implementation phase can begin in earnest. It is helpful to maintain a checklist of tasks, responsibilities, and milestones to ensure that all aspects of the project are progressing as required. Some important components to consider are:

- Design/audit work
- LED fixtures: types, purchase costs
- Installation labor
- Maintenance and performance verification
- Submission for utility for incentives

Procurement Options

Municipalities in Massachusetts can use a collective procurement model to purchase fixtures, as well as design and installation services. (See the Procure Energy Services strategy for more information.)

Fixtures-only purchases can be made from the statewide contract, FAC76: Maintenance, Repair and Operations (MRO) Products, Supplies and Equipment, Category 6: LED Street and Roadway Lighting.

Some purchases of lighting fixtures in this contract fall under the requirements of statutes governing building and public works construction (M.G.L. chapter 149 and chapter 30 section 39M, respectively). The following table explains how those statutes apply to the contract, based on the ordering option and project type:

Project type	Order/Project Size Limit Under the Contract	Applicable Procurement Law for Projects Above Order/Project Limit
Fixtures for projects using municipal staff	No limit	N/A
Fixtures for multiple projects using hired labor (installation procured separately)	No limit	N/A
Fixtures for a single project using hired labor (installation procured separately)	$10,000	M.G.L. Chapter 30 Section 39M*
Fixtures and installation procured together	$10,000	M.G.L. Chapter 149 or Chapter 30 Section 39M*

* Consult the Inspector General's Office for guidance on the application of the construction statutes referenced above.

If a municipality intends to install fixtures in multiple locations, the following guidance will apply:

- If the work is going to be performed in phases and potentially by multiple installers (e.g., when installers are allowed to bid on portions of the work, even if one wins everything), municipalities may consider each phase/portion of the total scope of work to be a separate project. The contract does not impose a limit on the purchase of fixtures for multiple projects, as long as the fixtures are not required to be installed by "manufacturer certified" contractors. Municipalities may order all the fixtures at once and stock them or they may schedule separate deliveries for each project under the same purchase order.
- If the work in all the locations is going to be performed at the same time and is expected to be awarded to only one installer, it should be considered one project. The contract limits purchases of fixtures for such single projects with hired labor to $10,000.
- If the project falls under the category of "Purchase of Construction Materials without Labor," or if design and/or installation labor will be secured in addition to the fixtures themselves, the following options are available:

- Bid out the project separately under M.G.L. ch. 30, sec. 39M
- Projects under $100,000 can be contracted through the utilities and their preferred vendors pursuant to M.G.L. ch. 25A, sec. 14
- Projects over $100,000 can be competitively bid pursuant to ch. 25A sec. 11c or 11i as streetlight energy management services (EMS) solicitations that include design, audit, and installation work. MAPC can help with group procurements for EMS.

When crafting a solicitation for streetlight EMS and evaluating responses, consider some of the following questions:

- In the Management Capabilities and Project Experience categories, consider:
  - What type of experience does the respondent have working with municipal street lighting systems, particularly in the Northeast and specifically in Massachusetts?
  - How many years has the respondent been engaged in providing energy efficiency, street lighting, and performance contracting services?
  - How many full-time personnel does the respondent employ?
  - Do the respondent's maintenance and installation employees have any accreditations or pre-qualifications? (Note: All work must be performed by personnel having the minimum qualifications of MA Licensed Electricians and Journeyman Lineman certified as IMSA Roadway Lighting Level I technicians or higher, and be paid prevailing wages.)
  - What scope of services (auditing, design, construction, monitoring, operations, maintenance, training, financing, etc.) does the respondent offer? In particular:
    - Does the respondent offer services to upgrade the following: street lighting, controls, underground feeds, overhead feeds, foundations, pole placement, series circuits, parallel circuits, emergency response, call center operations, and other street lighting systems?
    - What is the respondent's general knowledge of latest street lighting technologies and associated life cycle costs?
    - What is the respondent's general ability and approach to help with financing and secure low rates?
    - What is the respondent's general ability to secure insurance policies?
    - Does the respondent operate a 24-hour call service with a toll-free number answered at all times by a person to receive outage reports with the capability for real-time work order dispatching for emergency calls? If so, for how long has it been in operation?
- In the Experience and Project References category, consider:

- Which of the respondent's past project experiences involve systems similar in type, size, or scope to the system described in the technical appendices, and/or in locations with similar geography or climate to municipalities in Massachusetts?
- Is the respondent able to provide lease purchase financing?
- What are the respondent's existing street lighting maintenance contracts like?
- Does the respondent have knowledge of utility tariffs, available incentives and rebates, and application processes?
- What are the respondent's relationships with lighting fixture, controls, and other related technology suppliers?
- What are the respondent's staff capabilities in terms of conducting technical analysis, engineering design, construction management, construction, training, and post-contract monitoring?

- In the Project Approach category, consider:
  - What scope of services (auditing, design, construction, monitoring, operations, maintenance, training, financing, etc.) is the respondent proposing? What is the respondent's approach to auditing streetlights and determining light output?
  - What equipment modifications, installations, or replacements does the respondent recommend? What are the potential energy saving opportunities? Does the respondent propose any special features, renewable technologies, advanced technologies, or any additional special features or services?
  - Does the respondent have facilities management and maintenance personnel to coordinate construction and avoid conflicts with other ongoing or scheduled projects?
  - Will the respondent use subcontractors, and if so, in what nature?
  - What is the proposed project schedule?
  - What is the commissioning and utility coordination process?
  - Does the respondent assume all responsibility for proper handling, storage and disposal of environmentally sensitive equipment?
  - What equipment ownership model does the respondent propose? What is the respondent's proposed service responsibility?
  - What is the nature and term of typical warranties that the respondent recommends?
- In the Pricing Methodology categories, consider:
  - What is the estimated cost per fixture or per municipality to compete a Technical Street Light Energy Audit?

- What is the proposed cost per fixture?
- Has the respondent accurately calculated utility rebates and incentives?
- What are the proposed installation costs?

Financing Options

A variety of options are available for the project team to consider for financing the project:

- **Tax-exempt municipal lease financing** – This is the recommended method for paying for LED projects upfront, as it doesn't affect municipal bond rating or debt levy.
- **Performance contract under ch. 25A** – With this method, guaranteed energy savings can be dedicated to debt service each year.
- **Bonds** – General obligation bonds and Qualified Energy Conservation Bonds (QECBs) are appropriate for projects with substantial up-front costs.
- **Operating funds** – If other energy projects have already been set up in the municipality and are generating savings, a case can be made to appropriate those savings for further energy efficiency improvements.
- **Capital projects** – An LED streetlight retrofit can be undertaken as a separate capital project, with a line item in the municipality's budget.
- **Grants** – Green Communities funds can potentially be used to cover the costs of acquisition, if acquisition costs are included as part of an overall funding request for LED streetlight retrofits. However, round 1 Green Communities funds can't be used to pay for streetlight retrofits. A municipality will have to wait for its next round of competitive grant awards to apply for any funding related to streetlight retrofits.

Glossary

Lighting Terminology

- **Correlated Color Temperature (CCT)** indicates how "warm" or "cool" the light a particular lighting technology generates is. CCT is measured in Kelvin (K). A higher value (>5,000K) indicates a "cooler"/bluer light color; a lower value (<4,500K) indicates a "warmer"/more orange light color.
- **Color Rendering Index (CRI)** indicates the light's ability to render colors across the spectrum. It is represented by a number between 1 and 100, where 100 is the full spectrum of visible light equivalent to the sun.
- **Illuminance** indicates the light intensity on a surface per unit area. It is measured in foot-candles (fc). 1 fc = 1 lumen/square foot.

- **Kilowatt-hours (kWh)** is a measurement of energy. It is calculated by multiplying the power draw (wattage) of a device by the amount of time for which it is drawing power (e.g., a 100W light bulb that is on for 10 hours uses 100 x 10 = 1,000 watt-hours = 1 kWh).
- **Uniformity** describes how evenly light is distributed across an area.
- **Useful life** is used for measuring LED fixture lifetimes. It is generally defined as the estimated time at which LED light output will depreciate to 70% of its initial rating.

Common Fixture Types

- **Incandescent lights** are the most out-dated and least efficient street lighting technology available, although utilities currently maintain a tariff for incandescent lights.
- **Mercury vapor (MV) lights** replaced incandescents in the '50s and continue to be a widely used technology today. Nonetheless, most Massachusetts cities and towns have replaced them with alternative technologies that are more efficient.
- **High-pressure sodium (HPS) lights** are the most commonly used technology by municipalities today. A typical 150W HPS fixture:
  - Draws approximately 183W of power
  - Has a CCT of 2,000K
  - Has a CRI of 22

  (Note: Low-pressure sodium lighting is also used on rare occasions. It is more efficient but the color rendering is worse than HPS.)
- **Metal halide (MH) lights** are also a commonly used lighting source. This lighting technology emits a very bright white to bluish light. The color of these lamps tends to shift over time. It is not uncommon to find a row of identical MH fixtures with each emitting slightly different color light. A typical 175W MH fixture:
  - Draws approximately 208W of power
  - Has a CCT of 4,000K
  - Has a CRI of 65
- **Induction lighting** transfers electric power via electromagnetic fields, rather than electric connections (electrodes). It is a more efficient method of transforming electric power into light. Induction lamps are also referred to as electrode-less lamps. Current technology of induction lighting provides a much higher color temperate and yields a cooler/bluer light than HPS lamps.
- **Light-emitting diode (LED), a.k.a. solid-state lighting,** creates a new potential for energy-efficient lighting. This technology can provide directional light emission and has a longer life than conventional light sources. In comparison to HPS and MH technologies, LEDs are also improving more rapidly in terms of color quality, optical design, thermal management, and cost. A typical LED fixture:

- Draws 150W of power
- Has a CCT of 6,000K
- Has a CRI of 75

Comparison of HPS and LED Outdoor Fixtures for Demonstration Site			
	Existing 70W HPS Fixture	**LED 3-Array Fixture**	**Optional LED 2-Array Fixture**
Total power draw	97W	72W	48W
Average illuminance levels	3.54 fc	3.63 fc	2.42 fc
Maximum illuminance	7.55 fc	5.09 fc	3.40 fc
Minimum illuminance*	1.25 fc	1.90 fc	1.27 fc**
Max/Min Ratio (uniformity)	6.04: 1	2.68: 1	2.68: 1
Energy consumption per fixtures***	426 kWh/yr	311 kWh/ yr	210 kWh/ yr
Energy savings per fixture	--	114 kWh/ yr (26.8%)	215 kWh/ yr (50.6%)

Table from US DOE "LED Application Series: Outdoor Area Lighting"
* Lowest measured or modeled for each fixture. IESNA guidelines call for at least 0.5 fc.
** Modeled results.
*** Energy consumption for the HPS system is based on manufacturer-rated power levels for lamps and ballasts, for the 3-bar LED unit on laboratory power measurements, and for the 2-bar unit on manufacturer-rated power levels, all multiplied by 4,380 hours per year.

Additional Resources

- "LED Application Series: Outdoor Area Lighting." U.S. Department of Energy. (2008) http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/outdoor_area_lighting.pdf
- "DOE Municipal Solid-State Street Lighting Consortium." U.S. Department of Energy. (2013) http://www1.eere.energy.gov/buildings/ssl/consortium.html
- "Qualified Products List." Design Lights Consortium. (2013) http://www.designlights.org/QPL
- Illuminating Engineering Society of North America. http://www.ies.org/
- "Considerations in Led Street Lighting in Massachusetts." Department of Energy Resources. (2011) http://mapc.org/sites/default/files/SL-MAPC-pres-Powelka.pdf
- "How to Use the Maintenance, Repair & Operations (MRO) Products, Supplies and Equipment Statewide Contract (FAC76)." Massachusetts Operational Services Division. (2012) http://www.mass.gov/anf/docs/osd/uguide/fac76-05-03-2013.pdf

- "Improving Efficiency in Municipal Street and Public Lighting." Efficiency Vermont. http://www.efficiencyvermont.com/for_my_business/solutions_for_me/municipal_and_state_government/general_info/municipal_street_lighting.aspx
- "Solid-State Lighting GATEWAY Demonstration Results." U.S. Department of Energy. (2013) http://www1.eere.energy.gov/buildings/ssl/gatewaydemos_results.html
- "Ann Arbor's LED Streetlight Program." City of Ann Arbor, Michigan. http://www.a2gov.org/government/publicservices/systems_planning/energy/Documents/LED_Summary.pdf
- "Los Angeles' LED Street Lighting Energy Efficiency Program is Shining Bright." Alcon Lighting. (2011) http://www.alconlighting.com/energy_efficient_blog/2011/08/19/los-angeles-led-street-lighting-energy-efficiency-program-is-shining-bright/
- "City of Anchorage, Alaska" Cree. (2008) http://www.betaled.com/us-en/LEDApplications/street-lighting/City-of-Anchorage-Alaska.aspx
- "LED Streetlights." Seattle City Light. (2012) http://www.seattle.gov/light/streetlight/led